Efficacy of Aerial Surveys for Northern Goshawk Nests in Wisconsin

Loren Ayers & James Woodford

Bureau of Integrated Science Services, Wisconsin Dept. of Natural Resources

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SUMMARY:

This report summarizes aerial survey methods used to detect Northern Goshawk nests in Wisconsin, the efficacy of those methods, and recommendations stemming from 2 years of survey trials. Observers detected 8 of 13 (62%) Northern Goshawk nests during helicopter surveys in 2001 and 9 of 27 (33%) nests in 2002 for an overall 43% nest detection rate. Video tape shot from the nose camera of the Bell 407 in 2002 captured identifiable images of 27% of sample nests occurring within 20 m of transect lines. We project that percent conifer cover in the canopy, distance, nest tree species, observer experience level and snow conditions influenced nest detection rates; however, sample size and continued problems with accurate measurement of distance prevented detailed analysis. In addition, a number of factors in 2002 combined to make survey conditions less favorable and may be responsible for the lower detection rate. These included seven nests ≤ 10 m from the transect line (under the helicopter), helicopter type and seating configuration (Bell 407 vs. Bell 47), lower observer experience and fresh snow on branches and nests. Effective survey width appeared to be ~75 m. The relative length of the survey window compared to breeding season ground surveys (4.5 months vs. 6 weeks) appeared advantageous, but had hidden problems associated with ground validation. Cost of aerial surveys was not a significant factor in 2002 since aircraft time was donated, thus only the economic analysis for 2001 was presented. Given the low nest detection rate, anticipated low sample size and high variance, ineffective surveys in high density conifer stands and the projected need for 120 more samples over a 2-3 year development window, we recommend discontinuing testing of aerial surveys. We further recommend the Forest Raptor Working Group reallocate helicopter and staff time toward acquisition of new nests in areas deemed potential habitat or in areas identified as priority for inventory by the Department and emphasize ground-based validation and monitoring efforts.

Note: This interim report is pending review and approval by the Forest Raptor Working and Advisory Groups of the Wisconsin DNR. It should not to be cited without permission of the senior author with the exception of internal Departmental use.

INTRODUCTION

The Northern Goshawk Working Group, under the lead of the Bureau of Endangered Resources, has committed to assessing the biological and legal status of the Northern Goshawk (*Accipiter gentilis*) in Wisconsin through monitoring trends in nest density and productivity. This effectively limits the annual survey window to a 45-day period between April 1st and May 15th. Prior to this, territorial breeding pairs may not be present or detectable at breeding sites, whereas later surveys may overlook failed nesting attempts. The resulting measurement errors artificially depress density estimates and inflate productivity estimates, respectively (Mayfield 1961, Willis 1981, Steenhof 1987), and therefore must be avoided. Previous attempts to survey Northern Goshawk nests within this window provided limited data and were discontinued due to logistical and economic limitations (Rosenfield et al. 1996, Rosenfield and Beilefeldt 1997, Meyer 2000). Therefore, in January of 2001, the WDNR Goshawk Working Group elected to test the accuracy and efficiency of helicopter aerial surveys in locating Northern Goshawk nest structures and for the resulting counts to be used in population or density estimation.

Biologists have used aerial surveys extensively to locate raptor nests and estimate population sizes (Henny et al. 1977, Leighton et al. 1979, Grier et al. 1981, Phillips et al. 1984, Looman et al. 1985). Aerial surveys have been attempted for Northern Goshawk nests in the past (Looman et al. 1985, L. Keith, Pers. Comm.), but under different objectives, in different habitats, or without quantitative assessment of visibility bias. Visibility bias is a significant source of error in most wildlife aerial surveys, and especially so for raptor nests in wooded environments (Ayers and Anderson 1999). Population estimates have been adjusted to account for visibility bias via Line Transect (Anderson et al. 1985), stratified and unstratified correction factors from complete ground counts (Leighton et al. 1979, Phillips et al. 1984), double-counts (i.e., two sample capture-recapture [Petersen] estimators; Grier et al. 1981, Seber 1982), and stratified double-counts (Henny et al. 1977).

While providing significant improvements over uncorrected count data, these techniques have shortcomings that limit their utility in many raptor surveys. Line Transect methodology assumes the probability of detection on the center-line is perfect which can be met in few, if any, raptor nest surveys. Adjustment for violation of this assumption is difficult (Buckland et al. 1993:200). Furthermore, 40 samples are recommended as the minimum number for analysis via Line Transect programs; it is unlikely that aerial surveys for nesting goshawks in Wisconsin could routinely achieve this number. Heterogeneous detection rates, or nests with different detection probabilities, are problematic in Line Transect surveys (Buckland et al. 1993:99), unstratified correction factors from complete ground counts, and double-counts (Seber 1982:81). In double-count aerial surveys, where nest-detections are made from the same vantage point, heterogeneous detection rates will result in a negative bias in population estimates (Pollock and Kendall 1987). This situation can be tenuated by pre-survey (Henny et al. 1977) or postsurvey stratification (Rivest et al. 1995), but stratification is of limited utility when multiple factors influence nest-detection rates, when detection gradients are related to continuous variables (e.g., percent canopy cover or distance), or when the stratification criteria cannot be extrapolated to the entire area being surveyed (i.e., the sampling "universe"). Complete ground counts are not feasible for Northern Goshawk nests in Wisconsin (Meyer 2000), thus eliminating techniques based on this form of visibility bias correction and finally, double count surveys, as the name implies, require that a proportion of sample units be covered twice - an unrealistic expectation considering the expense and time involved in helicopter surveys.

In contrast, Ayers and Anderson (1999) demonstrated that variable nest detection rates can be quantified and corrected with "adjustable" or predictive correction factors to obtain more accurate population estimates, even in situations with modest nest detection rates (40-60% detection). The technique, called Sightability Modeling (Steinhorst and Samuel 1989, Unsworth et al. 1994), uses a logistic regression model based on variables associated with nests seen during surveys to estimate and correct for the number of nests missed. Sightability modeling assumes objects (nests) have non-zero detection probabilities but does not require an equal detection rate among objects. Furthermore, sightability trials, which are used to collect model building data, do not require complete enumeration of a test population, but simply that a known subset of representative nests be available for trials.

The Ferruginous Hawk nest sightability model developed by Ayers and Anderson (1999) is currently the only known application of Sightability Modeling to nesting raptors. The model, based on 255 aerial survey samples, provided mixed but somewhat encouraging results during validation tests in Wyoming. In the best scenario, observers saw 17 of 39 nests (43.6%) and the model predicted $N = 36 \pm 14$ nests (90% CI); an error rate of -7.7% for the point estimate and a Coefficient of Variation (CV) of 0.38 on the confidence interval. The worst model performance resulted from a trial where 14 of 59 nests (23.7%) were seen by observers and the model predicted $N = 71 \pm 63$ nests (90% CI). This was an error of +20.3% on the point estimate and a CV of 0.89. The model estimates, with 90% CIs, captured the actual population in 3 out of 4 data sets tested.

Precision of the Sightability estimator is based on three sources of variance; model error, visibility correction error, and sampling error (Steinhorst and Samuel 1989). Precision is maximized when: 1) Large sample size is attained in the development phase (reducing model error), 2) A large proportion of the population is detected (reducing visibility correction error), and 3) The population is completely surveyed (eliminating sampling error). In the Ferruginous Hawk model, visibility correction error was the main contributor to the variance (82% in the first validation, 92% in the second) with model error contributing the remainder (Ayers and Anderson 1999). It is important to note the authors *did not report sampling error* due to complete coverage of their study area. In contrast, aerial surveys for nesting Northern Goshawks in Wisconsin would have to include sampling error since complete coverage of the species known extent would be impractical.

With the cautionary notes on the applicability of various survey techniques and the compelling interest to test aerial surveys demonstrated by the Department, L. Ayers' recommendation in 2001 was to evaluate

Sightability Modeling for application to Northern Goshawk nests in Wisconsin. The project was designed to be implemented in stages with several evaluation points (Table 1), the first three of which are covered in this report. Based on the recommendations of Meyer (2000; Append. A) and the findings of Ayers and Anderson (1999), we established several criteria as quantitative measures of interim success. First, overall nest detection rates should be >50% for reasonable precision of the final density or population estimate. Second, the detection function over distance should allow for reasonable survey interval width (≥100 m / side of the aircraft; 200 m total coverage) since this would have a strong bearing on economic viability of future surveys. Since aircraft time was donated in 2002, cost estimates were maintained from the 2001 interim report in the event the Forest Raptor Working Group deemed it necessary to re-contract for a Bell 47.

Table 1. Staged evaluation of aerial surveys for Northern Goshawk nests in Wisconsin using helicopter cost estimates from 2001.

# Samples	Product	Approx. Cost
10	Tentative indication of aerial survey viability	$10,000
20	Rough estimate of overall detection rates	$18,000
40	Preliminary evaluation of variables influencing detection rates	$36,000
80-100	Begin development of a sightability model to adjust for bias	$90,000
120-160	Functional sightability model	$144,000

GOAL

Determine if helicopter aerial surveys are viable for locating Northern Goshawk nest structures and estimating population size or nesting density in Wisconsin.

OBJECTIVES (2001-02)

1. Determine the accuracy of helicopter surveys for locating Northern Goshawk nests
2. Evaluate potential precision of model estimates based on Objective #1
3. Conduct an economic evaluation of helicopter surveys for Northern Goshawk nests

STUDY AREA and METHODS

Study Area. Our survey sites were located throughout the Northern Highland Section of the National Hierarchical Framework of Ecological Units in Wisconsin (McNab and Avers 1994). Most sites were on or adjacent to the Northern Highland American Legion State Forest, the Flambeau River State Forest, or the Cheqaumegon-Nicolet National Forest. Forested upland habitat types were dominated by northern hardwood [sugar maple (*Acer saccharum*) and basswood (*Tilia americana*)], trembling aspen (*Populus tremuloides*), and mixed coniferious/deciduous stands. Specific stand types present in this region include: *Acer* spp.-*Abies balsamea*; *Acer* spp.-*Tilia americana*; *Acer saccharum-Tsuga canadensis-Betula alleghaniensis*; *Pinus strobus-Acer* spp.; *Betula papyrifera-Populus tremuloides*; *Picea mariana-Larix laricina*; and *Larix laricina-Thuja occidentalis* (Kotar 2002). Topography is flat to moderately hilly, with large areas covered by glacial outwash and end moraines interspersed with abundant lakes, streams and rivers.

Sample Selection. To obtain samples for trial aerial surveys in 2001, "Element Occurrences" for the Northern Goshawk were queried from the Wisconsin Natural Heritage Inventory Database (W. Smith, Bureau of Endangered Resources, WDNR) using the following criteria:

1. Records occurred during the breeding season (March 15 – July 1)
2. Records indicated the presence of a nest
3. Spatial data had an accuracy of = 1/8 mile radius
4. Records were = 5 years old

This query produced 25 potential nest structures. Five additional known nests were added within these sections by USFS and cooperating researchers. These samples were used for trial surveys in April, 2001, followed by ground truthing in May and November to ensure sample nests were indeed present, spatial data were accurate and to collect basic habitat variables associated with the site.

Sample and Survey Units. The statistical sample unit for this evaluation was an individual known nest structure. The outcome of the dependent variable was binary (0, 1), corresponding to nest structures missed or seen during aerial surveys. For this paper, "known" nest(s) or sample(s) refers to Northern Goshawk nests which were active (eggs laid) at some time in the past 5 years, in good condition at the time of the survey and which were confirmed during ground surveys by project staff or cooperating researchers. In 2001 we used Public Land Survey Sections (1mi^2; 2.59 km^2) containing ≥1 known nest as our aerial “survey unit” (Fig. 1). Section boundaries were used as the aerial survey boundaries. In 2002, we used 200 m wide, variable length belt transects as the “survey unit” (Fig. 2). Hereafter these may simply be referred to as “blocks” and “transects,” respectively. Sample unit (known nest) placement was random with regard to the length or width of transects; however, transect orientation was subjectively controlled to ensure the most efficient use of flight time. The change in survey unit configuration between years increased flight efficiency and safety (less turning), decreased GPS satellite acquisition problems and also reduced pilot fatigue due to less demanding navigation and flight requirements.

Aerial Survey Trials. Trial surveys were conducted from April 2-5, 2001, at 22 survey units using a Bell 47 helicopter (Fig. 1). This aircraft seated 3 individuals abreast with the pilot on the left side and observers in the middle and on the right. An instrument council limited the visible range for the middle observer and required the use of two separate search zones (Fig. 1). While this was not an ideal arrangement, the Bell 47 was the only affordable, properly certified helicopter available at the time.

Additional trial surveys were conducted on January 7 & 8, 2002, on 17 transects using a Bell 407 helicopter (Fig. 2). This aircraft seated the pilot in front, one observer on each side of the passenger compartment (viewing to the side and forward) and a camera operator sitting opposed to one of the observers. The Bell 407 had a significant "blind spot" extending from the transect line to ~10-15 m perpendicular distance which resulted in incomplete coverage by observers. To help cover this area and maintain a full survey interval, we used a nose-mounted camera to film the transect line (Fig. 2). Despite it's size, the Bell 407 was highly maneuverable, provided good lateral visibility and had significant reserve power which provided a wider safety margin than the piston driven Bell 47.

Five different observers were used during the course of the study:

1. **Observer #1** -- Extensive aerial and ground survey experience on a variety of raptor species (but not N. Goshawks). Coverage of 18 survey units in 2001 and 17 units via camera footage in 2002.
2. **Observer #2** -- Moderate aerial survey experience, primarily on Ospreys and Bald Eagles, and extensive ground experience. Coverage of 18 survey units in 2001 and 17 units in 2002.
3. **Observer #3** -- No aerial survey experience, but extensive ground survey experience with a variety of raptors including N. Goshawks. Coverage of 4 survey units in 2001.
4. **Observer #4** -- No aerial or ground survey experience. Coverage of 17 survey units in 2002.
5. **Observer #5** -- Bell 407 pilot; no aerial or ground survey experience for raptors; partial coverage of 17 units in 2002.

Survey units were flown at ~1.5 to 2.5 times the tree canopy height or roughly 27-46 m (90-150 ft) above ground level (AGL). Aircraft speed averaged ~56-72 km/hr (35-45 mph). In 2001 most transects within the survey blocks were flown on a north-south axis, but several were flown east-west due to wind conditions. In 2002 flight orientation varied with the design of individual transects. Ground snow cover was nearly 100% on all survey units in both years. In 2001 coverage averaged 16 $\pm$ 3 transects (STDV; range 8-24) per survey unit (block), depending on the spatial arrangement of suitable habitat, resulting in an average spacing of 101 m (1609 m / 16 transects). Time spent surveying blocks in 2001 averaged 28 $\pm$ 5 min (STDV; range 20 to 36). In 2002 transect length ranged from 8-14 mi (14-23 km) and took roughly 10-21 min to complete. "Suitable habitat" was leniently defined as any stand of trees, pole size (5-11" diam.; 13-28 cm) or greater.

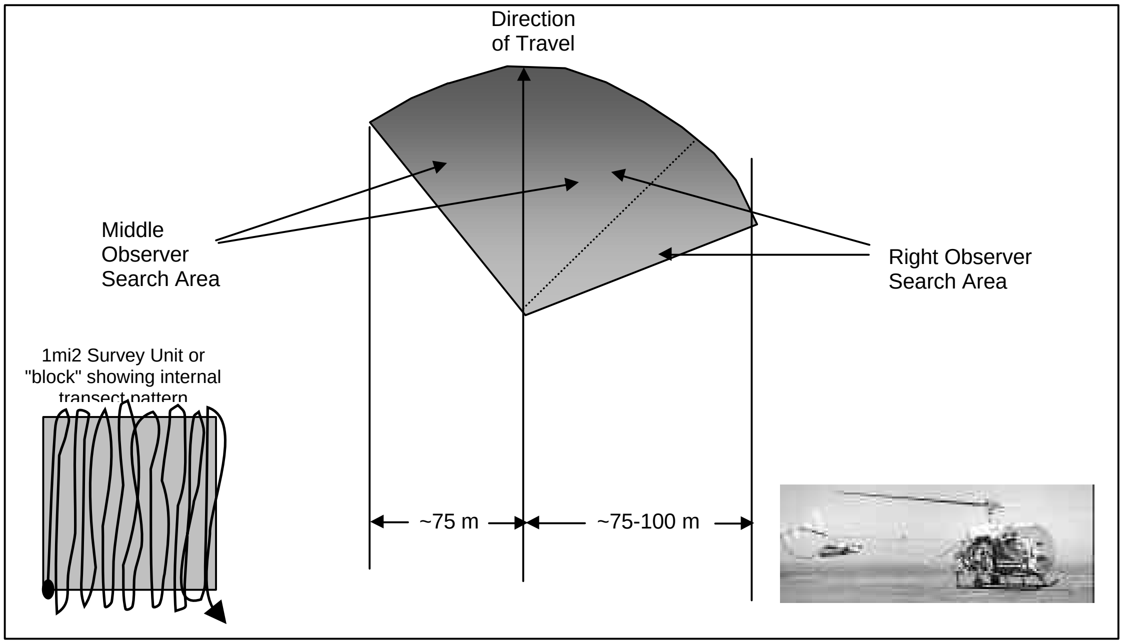

Figure 1. Typical block search pattern (left inset) and observer search areas and estimated transect widths (middle) from a Bell 47 helicopter (right inset) during Northern Goshawk aerial surveys in Wisconsin in 2001.

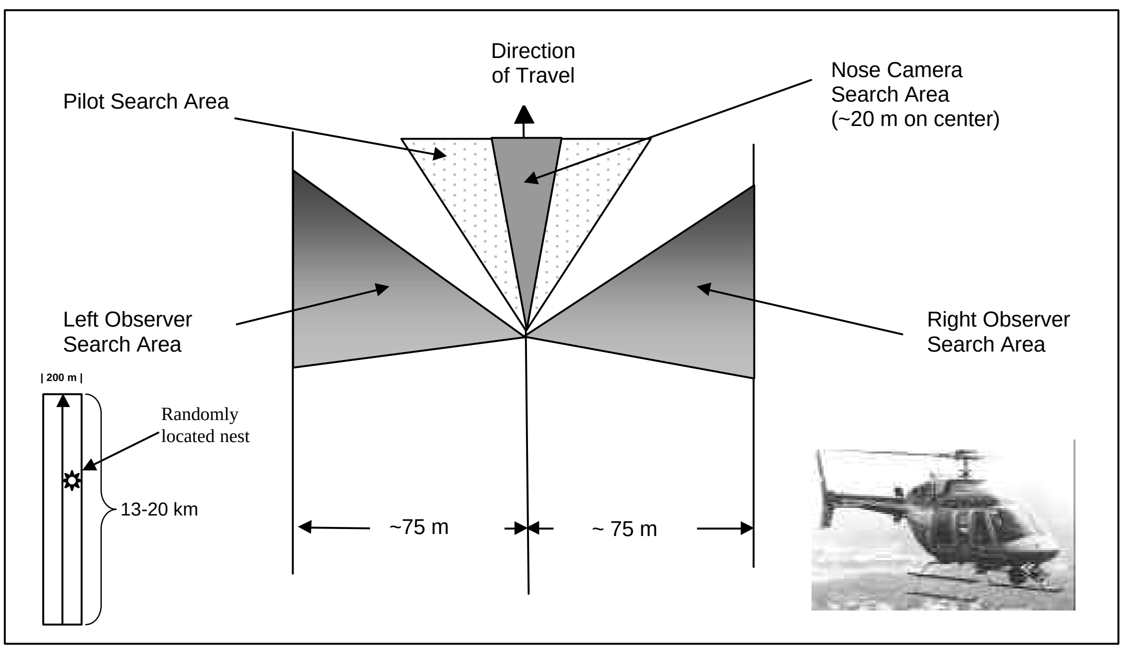

Figure 2. Example transect (left inset) and observer search areas and estimated transect widths (middle) from a Bell 407 helicopter (right inset) during Northern Goshawk aerial surveys in Wisconsin in 2002.

Data Capture. In 2001, spatial coordinates (latitude & longitude) of survey unit boundaries and known nest samples were uploaded to a GARMIN 12-Map® GPS for navigation during and after trial surveys, respectively. This same unit was used to record actual flight transects taken during surveys of the 1mi^2 blocks. In 2002, transect start and stop points were entered into the Bell 407 navigation system prior to surveys and a Trimble GeoExplorer® 3 (with differential correction using post-processed data files) was used to record flight line data. During trial flights we recorded: observer name, start and stop time, transect orientation, light conditions (flat/bright), precipitation, general topography, forest cover type, percent ground snow cover, presence / absence of snow on nests and branches, nest tree species and relative conifer cover (scale of 0 to 4 with 0 = none and 4 = complete). After aerial surveys were completed for blocks or transects, observers compared coordinates for known nests to what was found during the survey. If known nests were missed, we used the GPS unit to navigate to their location and conducted an intensive search. If a nest was found in this fashion, we recorded it as a "miss" along with all other data listed above. If the target nest was not relocated, USFS, DNR or cooperating personnel ground searched the area to verify nest presence. Similar independent data were collected for nest structures validated from ground searches.

GPS files collected during trial surveys were downloaded onto a personal computer using MapSource® (GARMIN 2000) in 2001 and Arc View® v. 3.2 (ESRI, Redlands, CA) in 2002 for graphical replication of each survey. The resulting maps and files were used to calculate number of transects used, side of the helicopter nests occurred on, observer responsible for the corresponding area, and the distance to nests encountered during the surveys. The statistical sample unit for this evaluation was defined as the individual nest *known* to exist during aerial surveys, thus we did not include nests located exclusively from the air even though this situation occurred on numerous occasions. "New" nests found from the air in 2001 were, however, used in the known population during 2002 surveys if they were ground-checked and deemed to be N. Goshawk nests through occupancy by adult birds, professional judgment, or information from cooperating biologists who knew the history of the nest(s).

RESULTS and DISCUSSION

Samples and Detection. Twenty-two blocks were surveyed in April of 2001 resulting in 13 viable samples (Table 2). Nests in 9 units had fallen out of the trees, were too small (weathered), were lost to logging or could not be relocated during aerial or ground surveys. In January, 2002, we surveyed 17 belt transects and gathered 27 viable samples (Table 2; > 1 sample / transect was possible because of clustered nests). Northern Goshawk nests were detected on 8 of 13 (62%) opportunities in 2001 and 9 of 27 (33%) opportunities in 2002 for an overall 43% (17/40) nest detection rate.

<u>Nest Tree Species.</u> The majority (38/40) of known nests targeted and encountered during trial surveys were in deciduous trees, primarily Red Maple (*Acer rubrum*), Yellow Birch (*Betula alleghaniensis*), White Birch (*Betula papyrifera*), and Trembling Aspen; we encountered one known nest in a Red Pine (*Pinus resinosa*) on two separate survey trials. Given caution due to small sample sizes, detection rates appeared to differ among nests tree species with a 60% detection rate in Trembling Aspen (n = 5), 54% in Sugar and Red Maple (n = 13), 40% in White Birch (n = 5) and 33% in Yellow Birch (n = 12; Table 2). The lower detection rate for nests in birch trees was likely due to an association with hemlock and other conifer species, which reduced visibility, and not a direct result of the tree species itself. Tree species may, in a minor part, account for the disparity in overall nest detection rates between years since birch tree nests constituted 38% of the sample in 2001 and 44% in 2002.

A habitat summary compiled by Rosenfield et al.(1996) found that 22% (8/37) of known Goshawk nests were in conifer trees; however, searching conifer trees from the air required a disproportionate amount of effort compared to their rate of occurrence in the landscape. The effort was discontinued after the first few trials in 2001 and observers concentrated primarily on deciduous trees. This caused significant problems for the Sightability Modeling effort since missing a segment of the population violates the base assumption that all objects have a non-zero probability of detection; obviously, objects (nests) with no chance of being seen cannot be mathematically adjusted in a model. We considered redefining the sample unit from an individual nest to a cluster of nests within a territory to reduce this problem. The misfortune of this approach comes in the difficulty of spatially defining a territory or nest cluster and, if successful, the subsequent requirement to ground-truth an equivalent area around each nest found during aerial surveys. And finally, a summary of Natural Heritage Inventory data showed that ~ 10% (8/77) of Northern Goshawk territories contained exclusively conifer nests (W. Smith, WDNR, Pers. Comm.), a fact that was insurmountable under any modification of the survey design or technique.

<u>Distance.</u> We were unable to collect accurate distance data in 2001; however, the authors estimated that nests could be identified out to ~50-75 m from the Bell 47. This was less than desired; however the pilot was able maintain 100 m transect spacing thereby allowing complete coverage of survey blocks. At times coverage overlapped between adjacent transects which improved the odds of detecting some nest structures. This may, in part, be responsible for higher detection rates in 2001 versus 2002 since several instances were noted in which nests were missed on one transect but were detected on an adjacent transect due to overlapping coverage. In these cases the miss was ignored and only data from the detection were used which is consistent with methodology used in ungulate sightability models (Unsworth et al. 1994).

In 2002, with improved flight line data from the GeoExplorer® 3 GPS, more accurate locations on known nests, and use of ArcView® software, we collected more accurate distance data. Nests were detected between 7 m and 74 m from the transect line (n=23; Table 3) in the Bell 407. Provisions can be made to ensure more nests

Table 2. Results of helicopter aerial surveys of Northern Goshawk nests in Wisconsin, 2001-02.

ISS-ER Nest Code	Transect Number	Year of Survey	Date of Survey	Target EO Detected	Observer Code	Detected on Video Tape	Distance (m) [estimated]	Nest Tree Species	Conifer Cover	Light Condition	Snow on Branches	Time Online
004D	Block	2001	0404	1	2	NA	-----	YEBI	3	2	0	28
007B	Block	2001	0405	0	---	NA	-----	REMA	2	1	0	32
013A	Block	2001	0403	1	1	NA	-----	TRAS	0	2	0	20
017A	Block	2001	0405	1	1	NA	-----	REPI	3	1	0	23
019	Block	2001	0405	1	1	NA	-----	REMA	2	1	0	35
019A	Block	2001	0405	1	1	NA	-----	REMA	3	1	0	35
022	Block	2001	0404	0	---	NA	-----	WHBI	0	2	0	28
028	Block	2001	0403	0	---	NA	-----	YEBI	3	2	0	30
030	Block	2001	0404	0	---	NA	-----	YEBI	---	2	0	36
030B	Block	2001	0404	1	1	NA	-----	REMA	0	2	0	36
032	Block	2001	0403	1	1	NA	-----	YEBI	3	2	0	----
044	Block	2001	0402	0	3	NA	-----	TRAS	2	1	0	----
044	Block	2001	0403	1	2	NA	-----	TRAS	2	1	0	----
044	1	2002	0107	0	---	0	-----	TRAS	2	2	1	12
026B	1	2002	0107	0	---	0	-----	REMA	1	2	1	12
084A	2	2002	0107	0	---	0	-----	YEBI	1	2	0	13
079	3	2002	0107	0	2	0	32	REMA	2	2	0	19
030	5	2002	0107	0	2	0	30	YEBI	1	2	0	14
030B	5	2002	0107	0	2	0	8	REMA	1	2	0	14
032A	6	2002	0107	0	4	0	26	YEBI	2	2	1	19
013A	6	2002	0107	1	7	1	[12]	TRAS	0	2	0	19
077	7	2002	0107	0	4	0	32	YEBI	2	2	0	19

032B	7	2002	0107	1	4	0	34	YEBI	2	2	1	19
022	8	2002	0107	0	2	0	11	WHBI	2	2	1	15
097	10	2002	0108	0	4	0	88	REOA	1	1	0	14
004F	11	2002	0108	1	6	1	[39]	SUMA	2	1	1	20
004D	11	2002	0108	1	6	0	12	YEBI	3	1	1	20

Table 2. Continued.

ISS-ER Nest Code	Transect Number	Year of Survey	Date of Survey	Target EO Detected	Observer Code	Detected on Video Tape	Distance (m) [estimated]	Nest Tree Species	Conifer Cover	Light Condition	Snow on Branches	Time Online
004C	11	2002	0108	1	2	1	10	WHBI	2	1	1	20
004F	12	2002	0108	0	2	0	8	SUMA	2	2	0	21
093	13	2002	0108	0	4	0	56	YEBI	2	1	0	18
007B	14	2002	0108	1	2	0	74	WHBI	2	1	0	----
007	14	2002	0108	0	2	0	6	REMA	2	1	0	----
076	15	2002	0108	1	2	0	31	REMA	1	2	0	----
086	16	2002	0108	0	---	0	-----	UNKN	---	1	0	----
085	16	2002	0108	0	2	0	38	YEBI	2	1	0	----
019	17	2002	0108	1	0	1	31	MAPL	2	1	0	----
019A	17	2002	0108	1	4	1	7	MAPL	2	1	0	----
017A	18	2002	0108	0	2	0	18	REPI	3	1	0	17
018F	19	2002	0108	0	2	0	4	WHBI	0	1	0	----
017B	19	2002	0108	0	2	0	4	TRAS	2	1	0	----

Table 3. Northern Goshawk nest observations in a 100 m survey interval derived from aerial transect surveys using a Bell 407 helicopter. A "0" corresponds to nests missed and "1" to nests seen during surveys.

ISS-ER Nest Code	Transect Number	Detected by Observers	Detected on Video Tape	Distance meters
018F	19	0	0	4
017B	19	0	0	4
007	14	0	0	6
019A	17	1	1	7
30B	5	0	0	8
004F	12	0	0	8
004C	11	1	1	10
022	8	0	0	11
004D	11	1	0	12
013A	6	1	1	12
017A	18	0	0	18
		4 / 11	**3 / 11**	£ **20 m**
032A	6	0	0	26
030	5	0	0	30
019	17	1	1	31
076	15	1	0	31
077	7	0	0	32
079	3	0	0	32
032B	7	1	0	34
085	16	0	0	38
004F	11	1	1	39
093	13	0	0	56
007B	14	1	0	74
097	10	0	0	88
Total		**9 / 23**	**5 / 23**	**0 - 100 m**

are detected on or near the transect line, thus the effective survey interval in the Bell 407 could be 75 m on each side of the aircraft, or 150 m total. This finding supports estimates made by the authors in 2001 (i.e., a 50-75 m interval), and while a seemingly minor disparity, it falls short of our minimum stated criteria by 25% (see introduction). To put the problem in perspective, even minimal coverage (say 20%) of the Northern Goshawk range in Wisconsin would require one transect every ½ mile (750 m) with a 150 m survey interval. Even the minimum 200 m recommendation would be onerous with one transects required every 0.62 mi (1000 m).

Camera Application And Utility. In 2002, film footage of trial aerial surveys was captured using a nose-mounted video camera and digital recording device in the Bell 407. The camera's survey interval or field of view was approximately 40-50 m wide (20-25 m / side) when the camera was set at zero magnification (28mm) and positioned at a 45^{o} downward angle at the standard 27-56 m AGL. Digital Video Cassette Pro 50 tapes from the aircraft recording system were converted to VHS and reviewed on a 4-head VCR capable of stop and slow frame presentation. Eleven known nests with accurate distance measures were encountered within 20 m of transect lines during surveys, 3 (27%) of which were identifiable on the video tape by Observer #1 (Table 3). Two additional nests were detected at 31 m and 39 m (Table 3) but were not included in the summary since we felt these observations were exceptional (the helicopter may have been above 27-56 m AGL) and they occurred well within the search zone of the observers The 27% detection rate provided little help or incentive to use the camera since observers saw 4 nests (36%) within 20 m, including the 3 seen on camera. While camera footage *can* be used to locate nest structures, a better solution to the blind spot associated with the Bell 407 would be to use an additional observer in the front right seat to search forward of the helicopter and close to the transect line so potential nest structures can be examined at the time of the survey.

Economic Analysis. The cost of conducting aerial surveys with the Bell 47 compared favorably with ground-based surveys (Table 4). Meyer (2000) estimated that ground searches of 16 mi^2 plots in 1998-99 cost approximately \$10,000 each or roughly \$625/mi^2. We estimate that helicopter surveys, with ground verification of nest status the following spring, would cost \$512/mi^2. Staff time, land access and a variety of other comparisons to ground surveys also can be made, but are left to summary in Table 5.

Factors Associated With Visibility Bias. Several factors which potentially influenced nest detection rates changed concurrently between surveys in 2001 and 2002, thus rendering the variables inseparable in statistical summaries. These variables included helicopter type and configuration, layout of search zones, survey unit shape (block vs. transect), observers, observer experience level and snow cover in the canopy. It was impossible with the current sample size and redundancy in the coding of independent variables to differentiate which were extraneous or influential factors. With this caution in mind, Table 2 can be used to obtain univariate survey results, if desired. We suspect the most influential variables were 1) percent conifer in the nest stand canopy, 2) distance, 3) nest tree species, 4) observer experience level, and 5) snow conditions.

Table 4. Actual and projected costs of aerial surveys and ground validation for Northern Goshawk nests in Wisconsin using a Bell 47.

Item	Unit Cost	Amount Used During Trials	Cost / 1 mi^2 (minutes)	Total Cost (Actual)
HELICOPTER				
Transport Time	$300 / hr	6.0 hrs	$78 (15.7)	$1,800
Survey Time	$300 / hr	10.9 hrs	$142 (28.4)	$3,270
Travel & Validation	$300 / hr	11.5 hrs	$152 (30.3)	$3,450
Subtotal		28.4 hrs	**$372** (74.4)	$9,710
HELICOPTER SUPPORT				
Crew Per diem	$130 / day	5 days	$23	$650
Fuel Truck	$75 / day	5 days	$13	$375
Hanger	$45 / day	4 days	$8	$165
Subtotal			**$44**	$1,190
AERIAL SURVEY CREW				
Per diem	$65 / day	2 people	$23	$585
Salary (not included)	$ 0 / day	2 people	$0	$0
Mileage / Vehicle	$20 / day	2 vehicles	$7	$200
Subtotal			**$30**	$785
GROUND TRUTHING COSTS *(estimated)*				
Per diem	$65 / day	2 LTE	$23	Unk
Salary (LTE;$13/hr)	$104 / day	2 LTE	$36	Unk
Mileage / Vehicle	$20 / day	2 vehicles	$7	Unk
Subtotal			**$66**	$0
Total			**$512**	$11,685

Table 5. Comparison of the ground and aerial based surveys for Northern Goshawk nests.

Factor	Helicopter	Ground
Expense	$512 / mi^2	$625 / mi^2
Error Rate (Nests Missed)	~57%	Unknown
Transect Spacing	~75 m	~100 m
Private Land Access	Good	Good
Physical Access	Excellent	Poor
Coordination & Logistics	Moderate	Very High
Permanent Staff Time	Moderate	Very High
Length of Survey Window	18-19 weeks	6 weeks
Length of Verification Window	6 weeks	(concurrent with survey window)
Data on Other Species	~5 Additional Species	~8 Additional Species
Intrusive (Public and Raptors)	High, short duration	Moderate, short duration

Factors Associated with Population Estimation. The following factors, derived from preliminary results, literature review and general statistical principals, will have substantial and largely negative bearing on aerial surveys of Northern Goshawk nest structures:

1. **Low Overall Nest Detection Rate** - Trial aerial surveys indicate a 43% nest detection rate for Northern Goshawk nest structures; less than the minimum of 50% recommended in the project scoping document. We project the detection rate would stabilize at this, or a lower level, given additional surveys. Reduction of the survey interval (distance) may increase nest detection rates but would further reduce economic viability and increase sampling variance through reduced coverage.

2. **Variance of the Population or Density Estimate -** The only other application of Sightability Modeling to raptor nests (Ayers and Anderson 1999) had a similar overall nest detection rate at 43%. The 90% confidence intervals ranged from ± 38% to ± 89% of the point estimate which did not include sampling variance. From this, we could reasonably expect the minimum attainable variance in the N. Goshawk application would be ≥ 40% CV.

3. **Population and Sample Size** - By most all accounts, the true breeding population size of Northern Goshawks in Wisconsin is relatively "small," therefore very precise population or density estimates would be required to detect modest (10-50%), but perhaps biologically important changes or trends in the population. When confounded with partial sample coverage (say 20% for this example) and detection bias, it follows that sample size obtained during implementation would be very small. Even a 50% decrease in the breeding population size might be represented by only 4 nests in the raw (uncorrected) survey results:

   100 breeding pairs X 20% coverage X 43% detection = 8.6 nests from which to base population estimates
   50 breeding pairs X 20% coverage X 43% detection = 4.3 nests from which to detect a -50% pop. change

4. **Indexing Actual Population Trend**. We know the actual *number* of breeding adults in a population can fluctuate substantially based on spring weather, prey abundance and a variety of other factors, however, the *proportion* of breeding adults in the population may or may not reflect actual differences in total population size or even population trend. This type of index is unstable for a long-lived species which may forgo breeding if conditions are not suitable.

5. **Missing Cohort of Nest Types**. 10-22% of the breeding population would have a "0" probability of detection due to nesting in conifer trees. We have found no suitable means to compensate for this fact.

6. **Helicopter Time.** Donated helicopter time is limited to approximately 1 week / year. Further coverage would require use and payment for a Bell 47 or other certified helicopter.

7. **Development Time & Cost.** Even with favorable interim results, we would need an additional 2-3 years to obtain sufficient samples for model development and the cost would exceed $100,000 if use of the Bell 47 is required. This is before application costs.

SUMMARY

Results reported herein were from preliminary research, therefore most of the conclusions are not definitive. Similarly, comparison to a model designed for the Ferruginous Hawk provides insight, but of course lacks certainty that we will see similar outcomes in the current application. The low Northern Goshawk nest detection rate and potentially complex model would result in excessive variance in the final estimate, likely >40% coefficient of variation. Sample size during application is projected to be very low with a high degree of fluctuation from year to year. This will cause population estimates to fluctuate from year to year (which may represent biological reality), but the associated high variance will preclude valid comparison of the difference in point estimates. Additionally, we were unable to modify the design or technique to overcome the conifer nesting cohort from being missed entirely. When these preliminary results and evaluations are taken *collectively*, they provide compelling evidence that helicopter aerial surveys are not viable for estimation of Northern Goshawk nest population size or nest density in Wisconsin.

RECOMMENDATIONS

1. Discontinue testing of aerial surveys for estimating N. Goshawk population size or density.
2. Emphasize long-term monitoring and demographic data collection at known territories and through partnership agreements with outside researchers
3. Emphasize new nest and nest-site acquisition through the Forest Raptor Monitoring Network
4. Emphasize training and education opportunities to support Forest Raptor Network Staff
5. Continue development of the habitat model
6. Redirect helicopter and staff time toward surveys of suitable habitat or into areas identified as priority for inventory by the Department
7. Evaluate the US Forest Service Conservation Assessment for the Northern Goshawk in the Midwest and consider Department participation through a conservation agreement with the Forest Service if appropriate.

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APPENDIX A: A PREPROPOSAL TO EVALUATE USE OF AERIAL SURVEYS FOR ESTIMATING GOSHAWK ABUNDANCE IN WISCONSIN

Michael W. Meyer, Bureau of Integrated Science Services, Wisconsin Department of Natural Resources, Rhinelander, WI 54501

NEED To increase sample size and efficiency, aerial surveys need to be evaluated as a means of assessing Goshawk nesting presence. Many Goshawk nests are located in conifers or far below the crowns of aspen, birch, and some hardwoods. It is unknown whether observers will be able to spot these nests from the air.

METHODS Aerial surveys (helicopter preferred over fixed-wing) will be conducted at 10 sites where Goshawks were known to nest in conifers in 1999 and at 10 sites where Goshawks nested in deciduous trees in 1999. An additional 8 sites will be chosen at random and surveyed. Size of quadrats could be reduced from 16 square miles to 4 square miles to expedite the surveys. It is important that the pilot and observer be blind to which of the quadrats are occupied. The pilot and observer should be experienced at conducting nest searches by air (Eckstein, Fud, Tesky, et al.). Once aerial surveys are completed the sites will be ground surveyed to validate the presence/absence of nesting Goshawks. Ground truthing would require a crew of 2 to complete four 4-sq mi. quadrats before leaf out . 3 crews would be required to completely survey 12 quadrats before leaf out. Methods used to survey Goshawks on the Tsongas National Forest may be evaluated to increase the efficiency of ground surveys (Croker-Bedford, USFS, pers. comm.). These methods include dawn listening stations prior to nesting and use of alarm calls following chick hatching. Manuscripts describing these methods were received from USFS in November.

SURVEY SITES Locations of known active territories in 1999 will be evaluated by project managers to determine which sites are most useful to examine the issue of detection in conifers and deciduous trees. Cooperation of R. Rosenfield, T. Erdman, etc. will likely be required to generate the list of potential survey sites. Cooperators in Minnesota (Andersen) and Michigan (Postupalsky) could also be approached. Random sites will be chosen via a random number generator. The sampling design should be reviewed and approved by a statistician (P. Rasmussen) before implementation.

DISTURBANCE The effect of aerial surveys on nesting Goshawks is unknown. Abandonment and nest failure are possible. Follow up surveys of nest outcome will need to be made and aerial observers should make detailed quantification of Goshawk response when it occurs during the aerial surveys. Outcome of nests impacted by aerial survey can be compared to outcome of a samples of nests that were not surveyed by air.

TIMING The aerial surveys will be conducted from the median time of egg laying based on observations of Rosenfield, Erdman, Doolittle, Postupalsky, and other regional Goshawk experts. It is anticipated that this will occur early-mid April, surveys should be completed by leaf out, late April southern WI to mid May northern WI.

COORDINATION Kennedy and Andersen (1999) in *Research and Monitoring Plan for northern Goshawks in the Western Great Lakes MN Coop FW Research Unit Report, pg 29* recommended that aerial surveys be evaluated as a means of conducting quadrat searches for nesting Goshawks in the North central U.S. It is important that the Wisconsin effort be conducted in a manner that can provide useful information to the regional planning process. Contact with Kennedy and Andersen prior to surveys is recommended.

BUDGET   To be determined